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MICHELSON'S ECONOMIC VALUE[1]

IN the year 1896 Albert A. Michelson took a new egg into the nest over which he brooded—or the department on which he sat—at the University of Chicago, and after an incubation period of twenty-five years—so long a time did it take to prove that the egg had ever been fertilized at all—he at last had it hatched and sufficiently feathered to justify pushing it out of the nest and bidding it go scratch up its own worms.

To-night, Mr. Chairman, you, representing the public which is obliged to supply the corn-meal required to keep both Michelson and Millikan scratching, have brought us here to exhibit our worms and to let you see whether they are worth the price paid to get them. And as you will presently see that leaves me no choice but to take for the subject of my speech the length of Mr. Michelson's worm, or the economic value of Michelson. For if you ask him to explain, in terms that you can understand, the value of his work I think that you will be told to go to the interior of a star where the temperature is estimated to be 50,000,000° C., or even to a hotter place, if such there be, described by a familiar monosyllable especially beloved by men like Michelson trained for the sea. For Mr. Michelson is wont to say that the sole reason, and the good and sufficient reason, why he spends so much time trying to measure the velocity of light to one part in three hundred thousand is simply that he likes to do it.

But I am going to make bold, now that I have left the nest and am where he can no longer reduce my rations, to contradict him and to tell you, and to tell him, that that is not the sole reason, nor is it the good and sufficient reason. (You see, Mr. Michelson, the young rooster, after the immemorial manner of young roosters, is questioning the old cock's right to do just exactly as he "damn-pleases" in the hen-yard.) To prove my point I have only to call your attention to the fact that if Mr. Michelson had "chosen" to spend his days and his nights sitting on a log pounding it with the butt end of a hatchet he would soon have found himself in a straight-jacket in the nearest institution especially provided by the state for the care of the deranged.

[1] Address delivered at the dinner of the Society of Arts and Sciences held in New York on February 22, 1929, upon the occasion of the presentation of the gold medal of the society to Messrs. Michelson and Millikan.

In a word, the reason you, the public, support Michelson's work on ether drift and the velocity of light, and the reason he sticks at those measurements like a burr to a collie-dog, is that both you and he *have faith in the worth-while-ness* of those measurements. And the real reason that he tells the reporters that he does it merely because he likes to is that he knows that if the reporter hasn't already "got religion" it can't be pumped into him in two minutes. There are some things that one can not explain for the next edition of the tabloid newspaper.

But the matter goes still deeper. It is rarely that a scientist himself knows just where his particular increment to the sum total of human knowledge is going to fit into "the whole," or find its relations to other increments. Galileo was not looking for useful applications when he was rolling his marbles down the inclined plane to discover the laws of force and motion, nor Kepler when he tried to understand the orbits of the planets, nor Newton when he deduced the law of gravity from observations on the moon, nor Volta when, merely toying with contact electrical effects, he laid the foundations for an understanding of electrical potentials; but all of them undoubtedly *had confidence in the value of knowledge* in enabling man to live more wisely in his world, not perhaps so much in enabling him to raise more cabbages to the acre, but, much more important than that, *in preventing him from wasting his time and his energies in chasing illusions,* in enabling him *to direct his thinking and his acting toward realities* instead of toward will-o'-the-wisps. It is only in looking back from our vantage point of centuries that we see that these men by their researches were actually *ushering in a new civilization.*

Has the time yet come when we can look back upon the particular type of activities, exceedingly precise physical measurements, which Mr. Michelson has followed, and say that from the standpoint of the hard-boiled business man who has had to pay the bills they have justified themselves? It is much too early now to balance the books, and will probably be too early for centuries to come, for the inspiring thing about work in the field of science is that *every bit of new knowledge becomes from the moment of its discovery the heritage of all future ages,* enabling coming man, as long as mankind endures, to live just so much more wisely than past man has known how to live. But in the case of Michelson's work I think we can even now get an inkling—a mere suggestion—of some of its economic values or at least its economic possibilities. Of course these may be either positive or negative—there are always some entries on both sides of a ledger—and since Mr. Michelson always inspired me by example to be strictly honest whatever happens, I am going to begin by presenting one of the liabilities instead of the assets. This one has to do with that particular nearly-bad-egg that he had to incubate for twenty-five years before it hatched and matured sufficiently to justify him in pushing it out of the nest.

When in 1917 I made the best determination I could of the value of the electron I had to use in getting the final quantity the best value then available of the velocity of light, I went to Mr. Michelson and asked him within what limits I might count upon his determination of the velocity of light. He replied, "To one part in ten thousand." So I chose for my computations the value $c = 2.999 \times 10^{10}$ cm./sec., the nearest value, to four places of accuracy, to his mean, and since my accuracy in the determination of e could not be more than one part in a thousand I thought I should never have to bother about changing e because of anything that might happen to the velocity of light. But last year, unfortunately for me, Mr. Michelson made a new and most accurate determination of c, which is one part in 3,000 instead of one part in 10,000 lower than my chosen value. Also, because of two new determinations of the absolute value of the ohm—experiments of quite the Michelsonian type though made by others—I find that my value of e is probably affected because of the change in this last constant by one part in two thousand, and these two changes being in the same direction, I am obliged to change my value of e by about one part in a thousand so that it becomes 4.770×10^{-10} instead of 4.774×10^{-10}.[2] This is such a wound to my pride

[2] The reason I have not heretofore made the foregoing readjustment in my value of e is, first, that it is of no particular significance anyway (see below); and, second, that I have until recently doubted its legitimacy.

In the presentation of the best values of widely used physical constants I have heretofore questioned the wisdom, or even the correctness, of making a differentiation between so-called international units and absolute units before a suitably authorized international commission had recognized that difference, since otherwise such differentiation would rest merely upon some individual's *estimate* of the superior reliability of some particular new determination or determinations over the weighted mean of the whole series of determinations used by the international commission which in 1908 and 1911 fixed upon the international units. However, Professor Raymond T. Birge has called my attention to the fact that in view primarily of the close agreement between new determinations of the absolute value of the ohm by F. E. Smith (*Phil. Trans.*, 1914) and Grüneisen and Giebe (*Annal. Physik.*, 1920), the compilers of tables have actually recently begun to make the foregoing differentiation. It is because of this fact and because of Michelson's undoubted new precision in the measurement of the velocity of light that I have thought it worth while to begin herewith to recognize the effect of these changes upon the value of e.

But this change is actually only of academic interest, since it is in any case within the limits of my estimated uncertainty. The limit of accuracy of the oil-drop method is fixed by the uncertainty in the measurement

that I am thinking of trying to obtain heart-balm by instituting a breach-of-promise suit against Mr. Michelson. If I succeed, the economic value of Michelson will be about a hundred thousand dollars less than it is now. So much for the debit side of the account.

Let us now glance at an item or two on the other side of the ledger. The special theory of relativity may be regarded as merely a generalization of the famous Michelson and Morley experiment, another typical Michelsonian attempt to measure with great precision a quantity of fundamental importance, namely, the speed of the earth through the ether. As everybody knows, it came out negative, that is, no such speed, nor any trace of it, could be found, and after forty years of most painstaking repetitions, capped by Michelson last year, it still seems to be impossible to find any speed whatever of the earth with respect to the ether.

Einstein, in 1905, generalized the foregoing result by postulating that it is in the nature of the universe impossible to find the speed of the earth with respect to ether. This postulate rests most conspicuously upon, and historically grew chiefly out of, the negative result of the Michelson-Morley experiment. Now one of the most important consequences that Einstein drew from the special theory of relativity is that mass and energy are interconvertible terms—that radiant energy, for example, can not appear without the corresponding disappearance of mass. This startling conclusion, which amounts to the denial of the ancient doctrine of the conservation of mass as distinct from the conservation of energy, has in recent years met with three new and powerful experimental supports. The first is that the assumption that the sun is stoking his own mass into his furnaces, and thereby reducing his waist-band at a rate measured by the scales of 250,000,000 tons a minute, furnishes the only means the astronomer can now find of accounting for the enormous lifetime of the sun and the stars, as attested by both astronomical and geological evidence. The second is that the interconvertibility of mass and energy seems to be an established experimental fact in the special case of an electron moving with a speed close to that of light. The third is that the facts of radiation-pressure, discovered by Lebedew in Russia, and Nichols and Hull in America, about 1898, mean that ethereal radiation has the only distinguishing property of mass, namely, inertia. Further, the quantitative equation of relationship, namely, $mc^2 = E$, in which m is mass in grams, c the velocity of light, and E energy in ergs, follows inevitably from the theory of relativity, and three different quantitative tests of this theory, all involving very painstaking and very precise measurements of the Michelsonian type, have all now yielded results *in quantitative agreement* with the predictions, so that I think that all physicists and astronomers will now agree that the foregoing equation is a safe guide for the theorist of the present and the future. ***Historically, it is hard to see how it could ever have been arrived at without both Michelson's own very exact measurements, and others of the kind he has led the way in showing how to make.***

Now, whether that conception has any immediate commercial importance or not, if it is true, as we think it is, it is one of such stupendous significance for man's understanding of the universe in which he lives that its importance transcends all assignable money value, and Michelson's part in bringing it to light makes him a bigger world-asset than any billion dollar corporation in the United States, or than all of them put together.

But I am not through yet with the rôle played recently in human progress by refined physical measurements of the Michelsonian type. While Michelson has been driving ether-drift and speed-of-light experiments to the limit of accuracy in America, Aston in England has been setting himself a precisely similar task in determining, by the so-called isotope technique, the atomic weights of the elements.

The first result was the beautiful discovery that the weights of all the elements are exact multiples of a fundamental unit which is close to the weight of the hydrogen atom. I use the word beautiful in describing this discovery because of the amazing simplicity and orderliness with which it endows nature, inevitably suggesting that all the elements have been built out of hydrogen.

But while we are admiring the beauty and simplicity of this generalization, let me call attention to the interesting circumstance that even some of us physicists overlooked for years the result that everybody can now easily see, namely, that the foregoing exact-multiple law, first stated in 1913 and 1914, is in irreconcilable conflict with the preceding generalization, the Einstein equation. For if mass and energy are interconvertible, and if the masses of all atoms are exact multiples of a mass-unit, then there can be no emission or absorption of energy when these units go out of one atom, or into another. In other words, there can be no forces holding atoms together and

of the viscosity of air, which enters into it in the 3/2 power. In my determination of e I estimated the viscosity of air to be known to 1/20 per cent. If this is an overestimate e would be affected 1½ times as much, so that if Eddington's recent theoretical deduction of e, which is ½ per cent. higher than my value, is correct, the viscosity of air must be about .3 per cent. higher than I have estimated it to be. I do not think this can be the case.

preventing transmutations, and there can be no evolution of energy when such transmutations spontaneously occur, as they do in radioactive processes. These conclusions are obviously contrary to all experience so there must be something wrong with the isotope law unless we are willing to throw overboard Einstein's equation.

Just what was wrong was brought to light a year ago last summer, for the case of all elements except hydrogen, solely because of Aston's skill in *adding another decimal point to the accuracy with which he could measure the masses of the various atoms*—a typical Michelsonian accomplishment.

And these new measurements, along with Einstein's equation, enabled Dr. Cameron and myself to get about a year ago what seems to me to be the inevitable interpretation of the so-called "cosmic rays"—strange super-gamma rays which bombard the earth incessantly day and night, apparently without any measurable change in intensity with either direction or time. They are best observed and measured by sinking electroscopes in deep, high altitude, snow-fed lakes. Their easily observable ionizing effects are found to decrease rapidly with depth but, according to our as yet unpublished measurements of last summer, not to disappear entirely until depths of much more than three hundred feet have been reached.

With the aid of Einstein's equation and Aston's atomic weights Dr. Cameron and I have computed the energy that should be released in a radioactive change—a process which transforms one atom of accurately measured mass into another atom of accurately measured mass. The difference in the measured masses before and after the change should give, when multiplied by c^2, the energy evolved, also accurately known, and *the results are found to check with the computation,* thus giving credentials to the method.

The interesting result of this mode of approach is that it shows that *no radioactive or disintegrating process can occur which, according to Aston's measurements, can possibly produce a radiation more than one fourth as energetic,* i.e., *as penetrating, as our softest observed cosmic rays nor more than one thirtieth as energetic as our most penetrating observed cosmic rays.* On the other hand, the creation of the common elements out of hydrogen should, according to Aston's atomic mass measurements and Einstein's equation, release energies of just about the observed penetrating power—quite accurately the observed penetrating power according to Dirac's formula. But the exactness of the fit is not at this stage very important. The illuminating facts are, first, that only the *atom-building process* can produce cosmic-ray *bands* of anything like high enough energies, and, second, that the *sequence* of observed cosmic ray frequencies fits quite nicely the sequence of the atomic weights of *the abundant* elements, which are very few in number, for probably more than 95 per cent. of all matter consists of oxygen, magnesium, silicon and iron. Our conclusion is that *the evidence is very strong that the cosmic rays are the subatomic radio signals broadcasting the continuous creation of these elements somewhere.*

But where? Apparently not in the sun or in the stars, since all observers agree that the sun, the great hot mass just off our bows, affects by his presence *not in the slightest* the stream of cosmic rays flowing into the earth. Further, Dr. Cameron and I can find no effect of the Milky Way, nor of the nearest extragalactic system, the spiral nebula of Andromeda. We think, therefore, that the high temperatures of the stars are inimical to the clustering processes required for the building of the common elements out of hydrogen, and we conclude that *the intensely cold regions of interstellar space probably furnish the essential conditions for such atom building.*

Whether or not the foregoing conclusion is correct, Einstein's equation and Aston's curve alone, the former due partially to Mr. Michelson, the latter representing superrefinement in physical measurement of just the sort that Mr. Michelson is famous for, enable us to draw one definite and very important conclusion, namely, that *there is no energy available to man through the disintegration of any of the common elements.* Man will presumably some day learn to disintegrate the elements, but he will have to expend energy upon them to do it. *There is no appreciable energy available to man through atomic disintegration.* Radium, it is true, releases about a million times as much energy per gram in disintegrating as carbon does in burning, but there isn't enough of it, nor of any radioactive substance, to more than keep a few corner pop-corn men continuously going.

On the other hand, a practically unlimited supply of energy would be available to man if the hydrogen in water and elsewhere on the earth could unite, here on earth, to form helium, nitrogen, oxygen and the other common elements. This, we think, is just what is happening in interstellar space and thereby producing the observed cosmic rays, but the foregoing cosmic-ray facts seem to indicate *that this process can not take place on earth,* and if this is true, then man will, in the future as in the past, depend entirely upon the sun for his supply of available energy. To bring us up against such *realities* is the mission of men like Michelson. Inspiring realities they are, too, and their economic values are well-nigh unlimited, for we can direct our own efforts and our energies to better advantage with that knowledge. We have

not yet begun to utilize the solar energy that is available to us, and we shall do it better with the knowledge that it is probably all we have.

If you belong to the group represented by the Bishop of Ripon which fears the too rapid advance of science and lives in dread of the day when some unscrupulous, or careless, Dr. Faust may touch off the stupendous subatomic powder magazine and blow this comfortable world of ours into star dust, you may henceforth banish your hobgoblin and sleep in peace in the consciousness that the creator has realized the wisdom of introducing some fool-proof features into his machine. If, on the other hand, you belong to the group represented by Lord Birkenhead which anticipates that one fine day the scientist will transform this earth into a Lotus Land in which the atoms will do all our work for us while we lie in bed and keep our digestions good by ordering two atoms worth of massage between meals, then you may wake up, banish your idle Utopian dream, and get back to your job, reflecting that the best of life is in the striving, and that there is infinitely more fun in learning how to smash a resistant atom than there could be in lying on your back and watching it explode.

Michelson's economic value! In the last analysis there is nothing that is practically important at all except our *ideas*, our group of concepts about the nature of the world and our place in it, for out of these springs all our conduct. There is not an idea that I have advanced to-night, a conclusion that I have drawn from Einstein's equation, from Aston's curve, from cosmic ray data, that would have been possible had not somebody driven to the limit the precision of physical measurement, and much of it became possible because of Michelson's own superrefined experiments—so true has it been proven to be that human progress "grows out of measurements made in the sixth place of decimals." Not he, nor anybody else, saw at the time what bearings the results would have. He merely felt in his bones, or knew in his soul, or *had faith to believe* that accurate knowledge was important. But some of the bearings have already appeared and others will continue to be found for ages yet to be.

I personally owe *everything* to the fact that thirty-two years ago Mr. Michelson took me into his nest at the University of Chicago, and I personally believe that the United States has not had in this generation a greater economic asset than Albert A. Michelson.

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METEOR CRATER EXPLORATION

IN its genesis, characters and relations the Arizona meteoric bowl is unique, unless the pittings in Siberia made by a meteor fall in 1908 are comparable. The Meteor Crater with its association of iron meteorites is one of the scientific marvels of the world, but not yet properly appreciated by the public or by the scientific fraternity. Unfortunately the subject is involved in unhappy personalities.

A recent article (June, 1928) in the *National Geographic Magazine* gives a popular description of the crater, but is faulty in omission and in implication. It fails to give the proofs of meteor-impact origin; it omits the very interesting story of its exploration and study, and, most important, fails to give proper credit for discovering and publishing the evidence of its impact origin. On the contrary, the article by implication and by the photographs appears to give the credit for discovery to G. K. Gilbert and the U. S. Geological Survey. Naturally any account of the crater exploration and the discovered evidence would have required the name of Daniel Moreau Barringer, which was entirely suppressed.

Naturally and properly the implication in the article has been resented by Barringer, who at great cost in time, effort and money explored and probed the crater, marshaled and first published the facts, and so proved beyond any reasonable doubt the meteor-impact genesis. A very spirited correspondence, involving a number of friends of Barringer, has not yet obtained the *amende honorable*. There is here a question of scientific and journalistic ethics. The purpose of this writing is to tell the true story of the crater study and to establish the credit for the discovery and publication of the truth.

The masses of nickeliferous iron, known as Canyon Diablo siderites, have been found in great numbers, and of size up to 1,400 pounds, scattered over the Arizona desert a few miles south of Sunshine station on the A. T. and Santa Fe Railroad. During the late eighties or early nineties of the last century two parties, F. W. Voltz, at Canyon Diablo, and the Williams Brothers, at Winslow, made a business of collecting the meteorites, with the aid of Mexicans, and of selling them to institutions and collectors all over the world. In consequence the Canyon Diablo siderites are the most widely distributed of all meteorites. They were also the first to yield minute diamonds, described by A. E. Foote in the *Proceedings* of the American Association for the Advancement of Science, Vol. 40, 1892, pp. 279–283.

In the midst of the desert area over which the irons were distributed is the great crateriform pit, four fifths of a mile across at the top and about 450 feet deep below the surrounding plain. With the elevated rim of quartz dust and rock fragment it has, from the inside of the bowl, a vertical relief of 570 feet.

This association of the crater, then bearing the absurd name of Coon Mountain or Coon Butte, with the

meteoric irons that were scattered concentrically around the hole for a radius of four and five miles, was long ago examined by a party from the U. S. Geological Survey, headed by G. K. Gilbert. His reports, published in the thirteenth and fourteenth annual reports of the survey for 1892 and 1893, briefly refer to his visit to the locality and note the two hypotheses of origin of the crater, one that it was essentially volcanic or an explosion of steam, and the other that it was produced by the fall of a very large mass of meteoric iron. The latter report states that he had partially prepared a report of conditions as to the structure and origin of Coon Butte but it had not yet received final form for publication.

Upon invitation of the writer, and under the auspices of the Rochester Academy of Science, Mr. Gilbert made an address on August 22, 1892, before the American Association for the Advancement of Science at its summer meeting in Rochester, New York, devoted to discussion of the Coon Butte problem and favoring the volcanic theory. The relief map which he used on that occasion he presented to the writer. Later came his quite famous address before the Geological Society of Washington (read on December 11, 1895, and printed in SCIENCE, 3: 1–13, 1896, entitled "The Origin of Hypotheses Illustrated by the Discussion of a Topographic Problem." In this address he considered the theory of impact origin of the crater, but favored a volcanic genesis or some sort of steam explosion. The lack of any magnetic effect from a supposed buried mass of iron, under the meteoric theory, appears to have been a determining factor.

And there the matter rested for several years.

In 1902 Mr. S. J. Holsinger, an employee of the U. S. Land Office, mentioned the crater, in a casual conversation at Tucson, Arizona, to Mr. D. M. Barringer, a mining engineer and geologist of Philadelphia. Holsinger had not at the time visited the crater but had heard of it from Voltz, the trader at Canyon Diablo. Mr. Barringer was greatly interested, and the outcome was that Barringer and B. C. Tilghman, also of Philadelphia, to whom Barringer had communicated his suspicion that the crater was formed by a meteoric mass, organized a mining company to take title to the property and secured a patent from the U. S. government to the square mile which includes the crater. This patent bears the date of December 24, 1903.

With scientific curiosity and commercial enterprise exploration of the crater began in 1903 to locate the supposedly buried meteorite. An attempt was made to sink a shaft in the center of the crater, but at 200 feet quicksand was encountered and the attempt abandoned. Twenty-four holes were drilled in the central area of the crater, even to a depth of over one thousand feet. These failed to discover any meteoric mass but did discover oxidized meteoric iron and proved the continuity in undisturbed position of the deeper rock strata, with the non-existence of any volcanic chimney. No evidence of volcanism has ever been found in or near the crater.

With the efficient aid of Mr. Holsinger, who was put in charge of the exploratory work and continued in the employ of the company as superintendent until his death at the crater in 1911, Mr. Barringer collected a great amount of very interesting information. The evidence of genetic association of the crater and the siderites was so conclusive that Barringer and Tilghman had announcement of the impact origin of the crater made by the president of the Academy of Natural Sciences of Philadelphia on December 5, 1905. And in the *Proceedings* of the academy for that month Barringer and Tilghman published the first articles marshaling the facts for the impact origin of the crater. This volume of the *Proceedings* was issued in March, 1906. The money which was spent in proving the crater to be an impact crater was advanced by Messrs. Barringer and Tilghman.

In June, 1906, Professor J. C. Branner reviewed the publications by Barringer and Tilghman before the Geology Section of the American Association for the Advancement of Science in session at Ithaca, New York, but did not commit himself.

In August, 1906, the writer examined the crater and studied its associations, and in September, at the tenth session of the International Geological Congress, in the City of Mexico, exhibited the meteoritic and rock materials and affirmed the meteoric origin of the phenomena. (*Compte Rendu X Session,* 1906, page 144). Another paper read before the Geological Society of America at New York in December was published, with illustrations, in the *Bulletin* of the society, Vol. 18, 1907, pages 493–504.

In 1907 Dr. George P. Merrill also visited the crater and printed a description in the *Smithsonian Misc. Coll.* (Quarterly Issue), Vol. 50, part 4, 1908.

Subsequent to the publications noted above Mr. Barringer published other papers with further facts and convincing illustrations, principal among which is his paper read before the National Academy of Sciences at its autumn meeting at Princeton in 1909. This was privately published but was widely distributed among scientists. His later papers on the subject, in each of which he brings forward additional convincing proofs of the meteoric theory of origin, are as follows: "Further Notes on Meteor Crater, Arizona," *Proc. Acad. Nat. Sciences of Phila.*, September, 1914; "A Possible Partial Explanation of the Visibility and Brilliancy of Comets," *Proc. Acad.*

Nat. Sciences of Phila., August, 1916; "Further Notes on Meteor Crater in Northern Central Arizona (No. 2)," *Proc. Acad. Nat. Sciences of Phila.*, 1924.

These thorough studies prove beyond the slightest doubt the meteor-impact origin of the crater. No feature is wanting that might reasonably be expected under the impact theory. And, on the contrary, not the slightest suggestion of any volcanic action has ever been found. The impact origin of the crater must be accepted as fact, no longer as theory. But this does not determine the fate or disposition of the colliding body or its mass.

In the *Scientific American* for July, August and September, 1927, is an interesting summary of the discoveries at Meteor Crater by D. M. Barringer, Jr.

From 1893 to the present time the U. S. Geological Survey has by its silence tacitly held to the volcanic or steam explosion hypothesis, by entirely ignoring all the work of geologists since Mr. Gilbert's report, while the negative attitude of some members of the survey toward the impact origin is well known.

This attitude of the survey deserves criticism. The scientific evidence is before the court of scientific men. The writer as mutual friend of all the parties, and especially as a close friend of Dr. Gilbert, will now assume the unsolicited and delicate task of summing the case and of pronouncing verdict.

The cause or reason for the unscientific and unfair attitude of the Geological Survey is probably of a personal nature. It is possible that Mr. Barringer is *persona non grata* to some on the survey. Also it may be that the personal ownership of Meteor Crater by Mr. Barringer and its exploration as a quasi-commercial enterprise is made an excuse for not recognizing and publishing the dramatic truth. Of course that would advertise the property. But the survey gives attention to mines and other exploitations which are wholly commercial and in private ownership.

Another reason, and perhaps the chief one, for the survey's silence is that the history and the facts show that a mistake was made by an eminent and beloved member of the survey. Dr. Gilbert certainly did form an erroneous opinion. Such a reason for the attitude of the survey implies either that the workers on the survey are considered infallible, or if fallible, that the survey never admits an error.

The writer had intimate personal and scientific relations with Dr. Gilbert and yields place to no one in regard and admiration for him as a man and geologist. It is difficult to understand how he came to favor volcanism as the cause of Meteor Crater. Most certainly he later knew his mistake. During the years following the publications by Barringer and myself he never questioned the impact theory, as he surely would have done had there been any doubt in his mind. Subsequent to his report on the crater he made a study of the moon's craters and found evidence of their origin by impact.

No luster is added to Gilbert's fame by neglecting to admit the evident truth. Nor would admission of this error hurt his reputation. It is human to err. After twenty-three years of implied acceptance of Gilbert's findings by official silence, confession by the survey will of course be painful. The public as father-confessor is waiting. And, really, a little evidence of humility and admission of fallibility by a great bureau of the government would be something new. It might awaken more generous feeling on the part of the public.

As a great bureau of the people's government, and supported by public money, the survey has no ethical or legal right to suppress or withhold any geologic truth, for personal or any other reason. The silence of the survey on the important feature works an injustice against (1) Mr. Barringer, who has made sacrifices to discover and publish the facts; (2) the scientific world, which looks to the survey for geologic information, and (3) the general public, which is morally and legally entitled to the latest and best information on all scientific matters considered by the survey.

HERMAN L. FAIRCHILD
UNIVERSITY OF ROCHESTER

SCIENTIFIC EVENTS

AGRICULTURAL RESEARCH BUREAUS IN GREAT BRITAIN

PROGRESS has been made in bringing into effect the scheme submitted last December to the governments of the empire to establish eight bureaus for the collection and interchange of information in eight branches of agricultural science. It was then announced, according to the London *Times*, that, as a result of a representative conference held in London, detailed proposals had been made for attaching these bureaus to recognized research institutes and for financing them from a common fund formed by contributions from governments of the empire and controlled by an executive council representative of the governments.

The governing bodies of the institutes which were approached have all accepted the scheme. The proposals have received the wide approval of the governments of the empire. The executive council at a meeting held at the end of March was thus able to authorize the opening of three bureaus from April 1, of a fourth from May 1, and to contemplate the opening of the remaining four during the summer months.

Those already opened are the Bureau of Animal Nutrition (attached to the Rowett Research Institute at Aberdeen), the Bureau of Animal Genetics (at the Animal Breeding Research Institute, Edinburgh University), and the Bureau of Fruit Production and Storage (at the East Malling Research Station, Kent). These three bureaus are respectively under the direction of Dr. J. B. Orr, Professor F. E. Crew and Mr. R. G. Hatton. From May 1 the Bureau of Soil Science at Rothamsted (under the direction of Dr. Sir John Russell) will be open.

It is contemplated opening during the summer the Bureau of Animal Health (at the Veterinary Research Laboratory, Weybridge), the Bureau of Plant Genetics (other than herbage plants) at the Plant Breeding Institute, University of Cambridge, the Bureau of Plant Genetics (herbage plants) at the Welsh Plant Breeding Institute, Aberystwyth, and the Bureau of Agricultural Parasitology at the Institute of Agricultural Parasitology, St. Albans. These bureaus will be respectively under the direction of Dr. W. H. Andrews, Sir Rowland Biffen, Professor F. E. Stapledon and Dr. W. Leiper.

U. S. BIOLOGICAL SURVEY

THE U. S. Department of Agriculture has authorized the creation of a new unit of the U. S. Biological Survey. Its purpose is to meet more effectively the obligations of the United States under the Migratory-Bird Treaty with Great Britain by lessening the dangers threatening wild fowl from drainage and other causes, through the provision of areas of land and of water to furnish in perpetuity reservations for their adequate protection through acquisition by purchase, gift or lease. The field of work will extend throughout the United States, including Alaska.

"In order to carry out the purpose of the act," it was explained by Paul C. Redington, Chief of the Biological Survey, "it is necessary to ascertain by examination of the numerous potential areas to be found throughout the United States those that are best adapted for refuges, to make appraisals in order to determine their character and value, and to conduct other activities incident to their acquisition with the funds made available by Congress from time to time.

The units selected for migratory-bird protection will be more or less extensive areas of lowland, comprising marsh and woodland contiguous to or embracing water areas, or they may be areas that were formerly well suited as feeding and nesting grounds for migratory birds, but now useless by reason of drainage developments or evaporation and subject to restoration to their natural conditions. The Migratory-Bird Conservation Commission created by the act will consider and pass upon all lands recommended by the Biological Survey for acquisition for refuge purposes. The Secretary of Agriculture is chairman of the commission.

"In addition to having charge of the land acquisition under the Migratory-Bird Conservation Act, the new division will supervise all other land acquisition and cadastral survey activities of the Bureau of Biological Survey, including the Upper Mississippi River Wild Life and Fish Refuge and Bear River (Utah) Migratory Bird Refuge."

THE NATIONAL ARBORETUM

THE Secretary of Agriculture has appointed a committee of the department to confer with the National Arboretum Advisory Council as required by the Act establishing the Arboretum.

The members are: Dr. A. F. Woods, director of scientific work; Dr. W. A. Taylor, chief of the bureau of plant industry; Major R. Y. Stuart, chief of the forest service, and Dr. F. V. Coville, and Dr. W. T. Swingle, of the bureau of plant industry.

Members of the National Arboretum Advisory Council are: Frederic A. Delano, member, National Capital Park and Planning Commission, Washington, D. C., chairman; Dr. L. H. Bailey, author and botanist, Ithaca, N. Y.; Dr. John C. Merriam, president of the Carnegie Institution, Washington, D. C.; Mrs. Frank B. Noyes, Garden Club of America, Washington, D. C.; Mrs. Harold R. Pratt, secretary of the Garden Club of America, Glen Cove, Long Island; Harlan P. Kelsey, nurseryman, Salem, Mass.; Frederick Law Olmsted, landscape architect, Brookline, Mass.; Robert Pyle, chairman of the Botanical Gardens and Arboretums Committee of the American Association of Nurserymen, West Grove, Pennsylvania, and Professor Henry S. Graves, Yale Forest School, New Haven, Conn.

The National Arboretum, as authorized by the Congress, will be developed on a large tract of land in the District of Columbia, including reclaimed land near the Anacostia River above the Benning Bridge. It will be both an educational and recreational center, and an important adjunct to the scientific activities of the government, particularly of the Department of Agriculture.

To the fullest degree possible, it is expected, the management of the National Arboretum will collect plants and trees from all the regions of the world for cultivation, study and breeding in the grounds of the arboretum. Dr. Coville, one of the members of the departmental committee, has suggested the function of the arboretum in such phrases as a "living library of the plants of the world," and as "a five-foot shelf of the more important plants."

GIFTS FOR MEDICAL RESEARCH AT NEW YORK UNIVERSITY AND BELLEVUE HOSPITAL MEDICAL COLLEGE

GIFTS amounting to $122,000 for medical research for the current year and a campaign now in progress for $250,000 for special endowment have been announced by Dean Samuel A. Brown, of New York University and Bellevue Hospital Medical College. Included in the list are the activities of the Harriman Research Fund, which at the present time are devoted to research in pneumonia under the direction of Dr. William H. Park, professor of bacteriology and hygiene in the medical college and director of the Bureau of Laboratories, New York City Department of Health. The Harriman Research Fund, established by Mrs. Mary W. Harriman, has recently been allied with the university. Dr. William G. Lyle, Dr. Park and Dr. William J. Maloney are trustees of the laboratory, which is under the direction of Dr. K. George Falk. The staff of this laboratory, under Dr. Park's supervision, will devote its entire time to the perfecting and standardizing of the method of refining the serum for the prevention of pneumonia.

Other gifts announced are: the Lucius N. Littauer Fund of $25,000 for research in the cause and cure of pneumonia; an Anonymous Fund of $50,000, of which $38,000 is devoted to the study of rheumatism and heart disease, and $12,000 to pneumonia; $10,000 annually from Richard T. Crane, Jr., of Chicago, for research in hay fever, asthma and related diseases; $13,000 annually for three years from the Jeremiah Milbank Foundation for the study of infantile paralysis, and $6,000 from the Commonwealth Fund.

The campaign for $250,000 is being carried on by Mrs. A. F. Tiffany, with the help of friends, in an effort to endow the Cardiac Clinic established by Dr. John Wyckoff, associate professor of medicine and secretary of the University and Bellevue Hospital Medical College faculty. Mrs. Tiffany in past years has raised $5,000 annually for this clinic.

Extensive research into the cause of rheumatism is also being carried on in the university medical school laboratories. Under the active direction of Dr. Bret Ratner, researches are progressing into the causes of hay fever, asthma and other allergic diseases. Dr. Covell and Dr. Weyer are directing the study of infantile paralysis, made possible by the gift from the Jeremiah Milbank Foundation.

PHYSICAL LABORATORIES OF THE UNIVERSITY OF CHICAGO

GROUND has been broken at the University of Chicago for the new Bernard A. Eckhart Laboratory of Physics, Mathematics and Astronomy. The new structure will complete the Hutchinson Quadrangle, adjoining the present Ryerson Laboratory on the east.

Made possible by a contribution of B. A. Eckhart, Chicago lumberman for whom it has been named, the laboratory will cost $604,000 and will provide facilities for work now cramped in Ryerson Hall. First floor and basement will house research work in physics, except for a large lecture room seating 239. The departments of mathematics and astronomy, which have never been adequately housed, will use the second, third and fourth floors. There will be 9 classrooms, 39 offices for faculty and students, 38 research rooms for physics and a large reading room which will accommodate 88 persons and 50,000 books. There will also be a common room with kitchenette facilities and an exhibition room. It is planned to remodel Ryerson Hall for expansion of teaching and research projects in physics. Designed by Charles Z. Klauder, Eckhart Laboratory will conform to the Gothic tradition of the university buildings. It should be completed by the end of this year.

Buildings under way now at the University of Chicago or to be started during the year will cost over $9,000,000. In addition to Eckhart Laboratory they are: Sunny Gymnasium, the Social Sciences Building, two quadrangles of dormitories, two additional units for the university clinics, the Chicago Lying-in Hospital, the Power Plant and the Oriental Institute.

THE FIFTIETH ANNIVERSARY OF THE INCANDESCENT LIGHT AND MR. EDISON

PLANS for the world-wide celebration of the fiftieth anniversary of the invention of the incandescent electric light beginning on May 31 and ending October 21 in an international tribute to the inventor of the lamp, Thomas A. Edison, were announced by Mr. Paul G. Cravath, member of the general committee sponsoring the celebration, at a luncheon of the Bankers' Club of New York City.

President Hoover, in consenting to be chairman of the general committee for the celebration, which will be known as Light's Golden Jubilee, wrote: "I have your kind letter of March 30 requesting that I accept the honorary chairmanship of the sponsorship committee of the Edison Pioneers. I shall be delighted to act in any capacity that will mean a genuine tribute to Mr. Edison's services."

The celebration will be opened by a series of light festivals beginning at Atlantic City on May 31 to signalize Mr. Edison's contributions to the advancement and comfort of humanity, and will end in a great "festival of light," which will be observed in virtually every city in the United States on October 21, and in many foreign cities. A feature of the last night of the celebration will be general electric illuminations throughout the country.

Among the events in honor of Mr. Edison which will take place on October 21 will be a dinner given to the inventor by Henry Ford at Dearborn, Michigan, which will be attended by eight hundred leaders of American industry. On the same day, the completely restored Menlo Park Laboratories, where Edison perfected the electric light, will be dedicated at Dearborn. The laboratories, which have been restored by Henry Ford, will contain not only a record of the life and inventions of Edison, but a collection of his original tools and retorts. Eight carloads of discarded tools and primitive incandescent lamps which Mr. Edison threw into a pond many years ago have been sent to Dearborn under Mr. Ford's direction and will be exhibited in the museum.

A third feature of the day will be the dedication of the Edison Institute of Technology, founded by Ford with a gift of $5,000,000. The institute building is an exact replica of Independence Hall.

SCIENTIFIC NOTES AND NEWS

DR. A. A. MICHELSON, of the University of Chicago, left on May 8 for Pasadena, California, where he will continue his measurements of the velocity of light, using a vacuum chamber a mile in length.

DR. WILLIAM H. WELCH, now professor of the history of medicine and director of the new medical library at the Johns Hopkins University, was guest of honor at a dinner celebrating his seventy-ninth birthday on April 8.

AT the recent Charter Day exercises, the University of California conferred the degree of LL.D. on Dr. L. O. Howard and on Dr. Roscoe Pound, dean of the Harvard Law School. In presenting the degree to Dr. Howard, President Campbell said: "Energetic and able student of insects in their relations to the welfare of mankind; unsurpassed benefactor of the farmers of the United States and therefore a perpetual creditor of all his countrymen; esteemed and beloved leader in the councils of American science."

DR. ELMER A. SPERRY, engineer and inventor, has been elected "a member with distinction" in Tau Beta Pi, the engineering society. This honor has been conferred only once before. The initiation, followed by a dinner, took place on April 18 at the Hotel Astor, New York.

PROFESSOR MICHAEL I. PUPIN, of Columbia University, was the honor guest at a dinner given at Tucson on April 5 by the Arizona chapter of Sigma Xi. Dr. T. F. Buehrer, professor of chemistry in the university and president of the Arizona chapter, presided. Following the dinner Professor Pupin gave an address on "Ionization."

ONE hundred and fifteen members of the staff of the Mayo Clinic attended a dinner in Rochester on April 25 in honor of Dr. Russell M. Wilder, who will leave the clinic soon to become head of the department of medicine at the University of Chicago.

A COMMITTEE composed of Professors Borst, Doederlein, Romberg and Sauerbruck has awarded the Sofia A. Vordhoff-Jung prize for work on the etiology of cancer to Professor Katsusaburo Yamagiwa, of the University of Tokio.

PROFESSOR PIETER ZEEMAN, of the University of Amsterdam, has been elected an honorary fellow of the Physical Society of London.

DR. MAX RUBNER, of the University of Berlin, has been elected an honorary member of the Physiological Society of London.

DR. HUGO OBERMAIER, professor at the University of Madrid, has been elected an honorary member of the Anthropological Society in Vienna.

M. CHARLES ACHARD, professor of clinical medicine in the University of Paris, has been elected a member of the section of medicine of the Paris Academy of Sciences to succeed the late M. F. Widal.

Nature reports that at the annual general meeting of the Ray Society held on March 21, the following officers were reelected: *President,* Professor W. C. M'Intosh; *treasurer,* Sir Sidney F. Harmer; *secretary,* Dr. W. T. Calman. Dr. R. W. T. Gunther was elected a vice-president, and Mr. R. Adkin and Mr. R. Gurney were elected new members of the council.

COMMANDER RAYMOND S. PATTON, hydrographic and geodetic engineer, has been appointed director of the U. S. Coast and Geodetic Survey to succeed E. Lester Jones, who died on April 9. Mr. Patton joined the survey in 1904 and spent twelve years' field service in Alaska, the Philippine Islands and along the coasts of the United States, where he commanded one of the survey ships. In 1917, he was transferred to the Navy Department, where he served until April, 1919. Since that time he has been chief of the division of charts in the Washington office of the survey.

DR. BASIL E. GILBERT, acting director of the Rhode Island Experiment Station since February, 1928, has been appointed director.

DR. C. L. HOLMES, head of the college department of agricultural economics at Iowa State College and of the agricultural economics section of the experiment station, has resigned to become principal agricultural economist in charge of the division of farm management and costs of the bureau of agricultural economics of the U. S. Department of Agriculture.

DR. HORACE H. F. JAYNE, of Wallingford, Pa., authority on eastern art, has been elected director of the University of Pennsylvania Museum, filling the vacancy left by the death in January, 1927, of Dr. George Byron Gordon.

DR. CHARLES C. HEDGES, assistant director of the Johns Hopkins Hospital, has been appointed director of the Babies and Children's Hospital, a unit in the Columbia University Medical Center.

WILLIAM NEWTON has been appointed plant pathologist for the Dominion Department of Agriculture in British Columbia.

DR. JAMES DAVIDSON, chief assistant entomologist at the Rothamsted Experimental Station, has been appointed head of the department of entomology at the Waite Agricultural Research Institute of the University of Adelaide.

DR. H. A. BROUWER, professor of geology at the Technical University, Delft, Holland, has accepted a call as director of the newly founded Geological Institute of the University of Amsterdam. Dr. Brouwer will occupy the chair of general geology and petrology and expects to begin his work in October after his return from the East Indies, where he is leading an expedition in the island Celebes and where he will act as delegate to the fourth Pacific Science Congress.

LOUIS C. HILL, construction engineer of Colorado; Andrew J. Wiley, of Idaho, construction engineer on dam design of the U. S. Department of Agriculture, and William F. Durand, formerly of Stanford University, California, have been appointed consulting engineers to collaborate with R. F. Walker, chief engineer, who will have general charge of the building of the Boulder Dam.

DR. CHARLES A. BROWNE, chief of chemical and technological research in the bureau of chemistry and soils of the U. S. Department of Agriculture, has left for a year's leave of absence in Europe, during which he will visit various laboratories and experiment stations in England and on the continent, and also do some historical scientific research in the libraries.

THE second Northwestern University expedition to Dutch Guiana for the study of the Negro will sail from New York on June 14, under the leadership of Dr. Melville J. Herskovits, assistant professor of anthropology. In the upper reaches of the Surinam River, Professor and Mrs. Herskovits expect to spend six weeks studying the customs, laws, beliefs and language of the people.

DR. E. W. BERRY, of the Johns Hopkins University, addressed a joint meeting of the botany and geology societies at the University of Cincinnati on April 15 on "The Evolution of Floras."

DR. NASU, professor in the University of Tokyo, will leave for the United States on May 23. He will give lectures at the University of Chicago on population, food and emigration problems. Dr. Nasu expects to return to Japan next autumn after a journey through European countries.

VILHJALMUR STEFANSSON opened his lectures at Magdalene College, University of Cambridge, on April 20. His subject was "Abolishing the Arctic."

THE *Journal* of the American Medical Association reports that the San Diego meeting of the California Medical Association was held from May 6 to 9. The speakers and their subjects at the four general sessions included Dr. William S. Thayer, Baltimore, president of the American Medical Association, on "Sir William Osler"; Dr. John H. Musser, New Orleans, president of the American College of Physicians, on "Functional Disorders"; Edward R. Stitt, until recently surgeon-general of the Navy, on "Trends in Medical Aviation," and William J. Mayo, Rochester, Minnesota, on "The Enlarged Spleen."

DR. ALFRED CHARLES TRUE, formerly director of the office of experiment stations and later of the states relations service of the U. S. Department of Agriculture, died on April 23 in his seventy-sixth year.

DR. ALBERT BARLOW HALE, assistant professor of economic geography in the University of Porto Rico, for many years a resident of Chicago, died on March 31 in Rio Piedras.

M. ULYSSE GAYON, biologist, chemist and honorary dean of the faculty of sciences at Bordeaux, has died in his eighty-third year.

THE recent death of Professor Shozaburo Watase, of the University of Tokyo, was reported last week in SCIENCE. A correspondent writes: "Professor Watase came to this country in 1887, having previously taken the degree M.Agr. at Sapporo and D.Sc. at Tokyo. He was a graduate student and fellow at the Johns Hopkins University from 1887 to 1890 and received the degree of Ph.D. in the year last named. From 1890 to 1892 he was lecturer and assistant in zoology at Clark University, and from 1892 to 1899 he was at first reader and then assistant professor of zoology in the University of Chicago. During the summers of the years he spent in this country he was a regular attendant at the Marine Biological Laboratory at Woods Hole. By his stimulating intellect, his charming courtesy and his delightful sense of humor, he made many devoted friends among his associates and students. In 1899 he was called to the professorship of zoology and head of the department at the Imperial University of Tokyo and he continued in this position until made honorary professor at the pre-

scribed age for retirement in the Japanese universities."

IN accordance with action proposed by the executive committee of the Federation of American Societies for Experimental Biology and the councils of the component societies and approved by the various societies two years ago, there will not be a spring meeting of the federation this year. The usual meeting of the federation is replaced by that of the Thirteenth International Physiological Congress at Boston, August 19 to 23, 1929. There will be no scientific sessions of the component societies of the federation as such. All arrangements in regard to papers and demonstrations are in the hands of the program committee of the congress, by whom a notice has already been sent out in regard to the submission of titles and abstracts. The usual business meetings of the four societies of the federation will be held on August 19, prior to the opening session of the congress. The secretaries of the congress are Dr. Edwin J. Cohn and Dr. Alfred C. Redfield, Harvard Medical School, Boston, Massachusetts.

DR. GEORGE E. JOHNSON, secretary of the Kansas Academy of Science, reports that the sixty-first annual meeting was held at the Kansas State Agricultural College, Manhattan, Kansas, from April 25 to 27. With the aid of local science organizations two special speakers were secured. Dr. Herbert M. Evans, of the University of California, spoke informally at a noon luncheon on "The Relation of Nutrition to Reproduction," and in the afternoon delivered a lecture on "The Function of the Anterior Hypophysis," both on April 26. Major Haig Shekerjian, of Fort Leavenworth, gave a lecture on "Chemical Warfare" on April 25. Besides the general program of fifty-two papers, there was held also a program of twenty-eight chemistry and physics papers, and a psychology program of eight papers. The Kansas Entomological Society met as a section of the academy and had a program of six papers on April 27. Other features of the meeting were the annual banquet, the address of the retiring president, L. D. Wooster, and three motion picture films. Officers were elected as follows: W. B. Wilson, *president,* Ottawa University; Hazel E. Branch, *first vice-president,* University of Wichita; W. M. Goldsmith, *second vice-president,* Southwestern College; R. Q. Brewster, *treasurer,* University of Kansas; G. E. Johnson, *secretary,* Kansas State Agricultural College; J. Willard Hershey, L. D. Havenhill, R. L. Parker and E. R. Wood, *additional members of the executive council.* The academy authorized the publication of Volume 32 of the *Transactions* of the academy. The 1930 meeting will be held at Hays, Kansas.

DR. A. M. PETER, secretary of the Kentucky Academy of Science, writes that the academy has just held a very successful annual meeting at Berea College, Berea, Ky. The attendance was good and much interest was taken in the papers presented. Officers elected are: Dr. Frank L. Rainey, Center College, Danville, Ky., *president;* Dr. Cloyd N. McAllister, Berea College, Berea, *vice-president;* Dr. A. M. Peter, Experiment Station, Lexington, *secretary;* Professor W. S. Anderson, Experiment Station, Lexington, *treasurer;* Professor V. F. Payne, Transylvania College, Lexington, *councillor* in the American Association for the Advancement of Science. The address of President Hutchins in the afternoon was an outstanding feature. After adjournment many of the members enjoyed an interesting hour inspecting the plant at Berea College.

AT the annual meeting of the Boston Society of Natural History, held on May 1, the following officers were elected for 1929–30: *President,* Charles H. Taylor; *vice-presidents,* Nathaniel T. Kidder, Glover M. Allen, William M. Wheeler; *secretary,* Clinton V. MacCoy; *treasurer,* Augustus P. Loring, Jr.; *trustees,* Thomas Barbour, Joseph A. Cushman, Laurence B. Fletcher, Frederic H. Kennard, W. Gordon Means, John C. Phillips. At the same meeting the annual "Walker Prize in Natural History," which was offered this year for the best paper submitted on any subject in the field of geology or mineralogy, was awarded to Dr. M. W. Senstius, of the department of geology of Rutgers University, for a memoir entitled "Studies in Weathering and Soil Formation in Tropical High Altitudes."

THE centenaries occur this month of the death of Sir Humphry Davy and Thomas Young, both long associated with the Royal Society and the Royal Institution, and both commemorated in Westminster Abbey. Young died in London, May 10, 1829, and is buried at Farnborough, while Davy is buried at Geneva, where he died on May 29, 1829.

THE tenth Annual Industrial Conference and the Personnel Research Federation will meet together at the Pennsylvania State College from May 16 to 18. Public addresses will be given by Dr. Walter V. Bingham, director of the Personnel Research Federation; Professor Walter B. Jones, University of Pittsburgh; C. S. Ching, United States Rubber Company, and F. A. Merrick, vice-president and general manager of the Westinghouse Electric and Manufacturing Company. The program centers around the general subject of "Personnel Problems and the Engineering Graduate."

ARRANGEMENTS for the reception of one hundred of Europe's most distinguished engineers and scientific

men, who will arrive in New York during the summer *en route* to the World Engineering Congress at Tokio, have been placed in charge of Roy V. Wright, president of the United Engineering Societies, as chairman of the New York reception committee, according to announcement from Maurice Holland, executive secretary of the American committee of the congress, of which Dr. Elmer A. Sperry, president of the American Society of Mechanical Engineers, is chairman. Mr. Wright will be aided by a committee of New York engineers. It is expected that the foreign engineers will arrive in separate delegations of approximately forty each from Great Britain and Germany, and the remainder from Sweden, Denmark, France and Italy, probably during August and September. Each of these countries has indicated that its foremost engineers will be included in its delegation. The foreign delegations will sail from the Pacific coast for Japan about the time that the American delegation, which is now composed of 235 engineers and their families from all parts of the country, sails from San Francisco on a special ship on October 11.

A GENERAL course in ecology is being planned to be held in Arizona between June 17 and August 16 to consist of a field study of the distribution of plants and animals as influenced by environment; a study of the various mammal, bird, reptile, insect and plant communities in the alpine-meadow, spruce-fir, yellow-pine, juniper-piñon, chaparral, short-grass, sage-brush, creosote-bush and desert-shrub areas at altitudes varying from 12,800 to 1,000 feet above sea-level. Emphasis will be placed on criteria for distinguishing the different plant and animal communities and the methods of measuring and evaluating soil, atmospheric and biotic factors. Eight semester hours' credit. Prerequisite, twenty semester hours of biological science. The instruction will be given by H. L. Shantz, Vernon Bailey, Walter P. Taylor, G. A. Pearson, Forrest Shreve, E. D. Ball, J. J. Thornber, C. T. Vorhies and W. G. McGinnies. Students will be required to furnish a cot and bedding. A charge of $75 will cover all field expenses. The class expects to be in the field throughout the whole period and will study the Kaibab Forest, Little Colorado, Painted Desert, Grand Canyon, San Francisco Peak, Coconino Plateau and Deserts of Salt River and Gila Valley.

SATURDAY afternoon lectures beginning at 4 o'clock at the New York Botanical Garden are being given as follows:

May 4.—"Tulips and Narcissi in Holland," Mr. John C. Wister, secretary, Pennsylvania Horticultural Society.

May 11.—"Wild Flower Preservation," Mr. P. L. Ricker, president of the Wild Flower Preservation Society.

May 18.—"Landscaping Your Own Garden," Mrs. C. Albert Schwab, Federated Garden Clubs of New York.

May 25.—"Azaleas and Rhododendrons," Mr. Henry Hicks, nurseryman and rhododendron specialist.

June 1.—"American Iris Breeders," Mrs. Wheeler H. Peckham, honorary curator, Iris and Narcissus Collection.

June 8.—"Day Lilies," Dr. A. B. Stout, Director of the Laboratories.

June 15.—"Flowers in the Perennial Border," Mr. Kenneth R. Boynton, head gardener.

June 22.—"Roses," Dr. Marshall A. Howe, assistant director.

June 29.—"Economic Fungi," Dr. Fred J. Seaver, Curator of Fungi.

THE London *Times* reports that work has begun on the building of an observatory for meteorological and scientific research on the *Jungfraujoch* (11,340 feet). The promoter of the scheme is the Swiss meteorologist, M. A. de Quervain, and the £20,000 needed for the carrying out of the enterprise has been raised.

A NATIONAL monument in Grand County, Utah, was established by presidential proclamation on April 22. It consists of two areas, known locally as the "Devil's Garden" and the "Windows," containing approximately 2,600 acres and 1,920 acres, respectively. Within these areas are extraordinary examples of wind erosion in the shape of gigantic arches, natural bridges, "windows," spires, balanced rocks and other unique wind-worn sandstone formations, the preservation of which is desirable because of their educational and scenic value.

PAUL G. REDINGTON, chief of the Bureau of Biological Survey, and W. L. McAtee, in charge of the bureau's division of food habits research, recently visited southern Georgia and northern Florida, where they viewed with H. L. Stoddard, stationed at Thomasville, Georgia, the results of Mr. Stoddard's study of quail conditions on southern game preserves. A group of prominent men have contributed more than $40,000 for a thorough study by the Biological Survey of the quail, its habits, migrations, diseases, propagation and enemies. Opportunity was afforded Mr. Redington and Mr. McAtee to travel extensively over the territory to see the application by owners of the game preserves of ideas developed by Mr. Stoddard, who is in charge of the work. A stop was made at Savannah, Ga., where, with United States Game Protector E. B. Whitehead, Mr. Redington had an opportunity to view the Savannah River bird refuge, maintained by the Biological Survey, along the Savannah River northwest of the city.

AN investigating committee of five members has been appointed by the U. S. Department of Agriculture to formulate plans and recommendations upon which the U. S. Department of Agriculture and cooperating agencies will base a program of soil-erosion investigations of nation-wide scope, according to an announcement made by Dr. A. F. Woods, director of the scientific work of the department. The investigations have been made possible by an item of $160,000 in the agricultural appropriation act of 1930, of which $40,000 is now available. The committee consists of A. G. McCall, chief of the division of soil investigation, Bureau of Chemistry and Soils (chairman); S. H. McCrory, chief of the division of agricultural engineering, Bureau of Public Roads; A. H. Clapp, in charge of the branch of research, Forest Service; J. G. Lipman, director of the New Jersey Experiment Station, and A. B. Conner, director of the Texas Agricultural Experiment Station.

THE Department of State has completed the arrangements for the participation of this government in an international conference to consider the revision of international classifications of the causes of death. This conference is to be held in Paris during October of this year and the invitation was extended through the French Ambassador. The following list of American delegates has been approved by the President: Dr. Timothy F. Murphy, chief statistician for vital statistics, Bureau of the Census, Washington; Dr. Haven Emerson, chairman, Committee on Reliability of Statements of Causes of Death, vital statistics section, American Public Health Association, New York City; George H. Van Buren, Metropolitan Life Insurance Company, New York City; Dr. William H. Guilfoy, director of records, City Department of Health, New York City; Dr. W. J. V. Deacon, director of statistics, State Department of Health, Harrisburg, Pennsylvania; Dr. Jessamine S. Whitney, Statistician, National Tuberculosis Association, New York City; Assistant Surgeon-General Rupert Blue, U. S. Public Health Service, Washington; Dr. Emlyn Jones, chief of the bureau of vital statistics, State Department of Health, Harrisburg, Pennsylvania; Edgar Sydenstricker, U. S. Public Health Service, Washington.

UNIVERSITY AND EDUCATIONAL NOTES

LOUISE ALLEN PRYOR has left her residuary estate of about $40,000 in trust to the New York Polyclinic Medical School and Hospital as a scholarship fund in memory of her father, who for many years was a professor at the institution.

THE Collège de France, founded by François the first in 1530, will celebrate its four-hundredth anniversary next year. A large attendance of delegates from French and foreign universities is expected.

IN the issue of SCIENCE for April 25 there was an error in regard to the Henry Barnard Davis professorship in geology at Yale University. Professor Chester R. Longwell has been appointed to this new chair, established by the mother and the aunt of Mr. Davis, who graduated from Yale College in 1911 and died recently.

PROFESSOR JOSEPH W. BARKER, of the Massachusetts Institute of Technology, has been appointed head of the department of electrical engineering at Lehigh University. He will succeed the late Professor William Esty.

HARRY M. GEHMAN, assistant professor of mathematics at Yale University, has been elected professor of mathematics and head of the department in the University of Buffalo to succeed the late Professor W. H. Sherk.

DR. JOSEPH MARCHAND HAYMAN, associate in medicine in the University of Pennsylvania, has been appointed associate professor of medicine in the school of medicine of Western Reserve University, Cleveland.

DR. C. H. GORDON has resigned as head of the department of geology at the University of Tennessee, but retains the professorship of geology, which he has held since 1907. Dr. G. M. Hall, associate professor, has become acting head of the department.

DR. CHARLES H. BEST, who was associated with Dr. Banting in the discovery of insulin, has been appointed professor of physiology at the University of Toronto to succeed Professor J. J. R. Macleod, who has accepted a chair at the University of Aberdeen, Scotland.

DISCUSSION

ON THE PHYLOGENY OF HORSES, DOGS AND CATS

DR. AUSTIN CLARK in the current (March 8) number of SCIENCE makes certain remarks about horses, cats and dogs to which I find it necessary to take exception. He cites the horse as an example of "linear evolution involving a time element," but states, correctly enough, that gaps are found in all these evolutionary lines, and that "many of these gaps appear to be real—that is, they were never, as far as we have been able to learn, bridged by so-called missing links." As a matter of fact, the fossil record

the horse is not at all an example of linear evolution. It exhibits at every stage of its progress the tendency, normal to all evolutionary phyla, to branch out into progressively divergent races. The more material we have to study, the more clearly and precisely does this appear. *E.g.*, the genus *Merychippus* first appears in our record with one very primitive and very variable species. In the next stage we find several subspecies, groups showing an exaggeration of the characters of certain individuals of the preceding stage. In the next stage these subspecific groups have become more distinct and are ranked as species. In the next stage we find some among them surviving as closely related genera, and in succeeding stages these genera become more distinct, more specialized in diverging lines of adaptation; all finally die out except *Equus*, which has in turn branched out into a number of distinct groups, with minor subspecies divergence appearing in each group. At the same time as this branching is going on there are many features of parallel progressive evolution. The analogy to the growth of a tree is a sound and real one.

That there are gaps even in so well-documented a record as the evolution of the horse is of course nothing new. Aside from criticisms made by those who have no adequate first-hand knowledge of the facts, it was emphasized by Gidley thirty years ago. One of the two most serious gaps to which Gidley called attention has been pretty well filled by subsequent discoveries. The other, between Eocene and Oligocene Equidae, still remains. Perhaps it will be filled during the next thirty years, perhaps not. A consideration of the true nature of the fossil record would make it clear that such "gaps" are to be expected. It is a continual branching out. At each geologic stage a race is represented by numerous species and subspecies scattered over a wide region. Some of the species inhabited the particular areas from which our fossils are obtained, and some of these may be known to us, rarely if ever all of them. Other species, inhabiting other areas, are necessarily unknown to us. Among these many species, one is the direct ancestor of the particular line whose evolution we are tracing, and we are fortunate if it is known to us. The others are collateral ancestors in various degrees of removal from the direct line. Unless we happen to have a succession of richly fossiliferous formations in the center of evolution and dispersal of the race, we can not expect to have a line of direct ancestry. But we can and do have in many cases a succession of collateral ancestors so nearly related to the direct genetic line as to afford, when critically studied with due recognition of their status, a clear record of the physical evolution of the race, sometimes in more general, sometimes in more detailed terms, according to the nearness of their approximation to the direct ancestral line. The "gap" between *Epihippus* and *Mesohippus* is probably a real one in the sense that *Epihippus* is not the direct ancestor of *Mesohippus*. But it is a fairly near relative, represents nearly the stage of evolution of the as yet unknown direct ancestor, and through evidence of various other members of the race living at the same time in other regions we may infer within close limits what the direct ancestor was like and where he lived.

Dr. Clark's misleading remarks about cats and dogs are more excusable in that the evidential facts as to their evolution have never been adequately brought together and presented as a whole. He tells us that "the gap between cats and dogs is broad, and it remains broad throughout the fossil record. Cats never become dogs nor dogs cats; but both are carnivorous mammals."

No one so far as I know ever suggested that cats became dogs or dogs cats, however it may be with monkeys and men; but it *has* been believed that these two diverse families of Carnivora are descended from the primitive Carnivora (Miacidae) of the Eocene epoch. In support of this conclusion there is a fairly close sequence of intermediate stages leading back from the specialized modern dogs to the generalized *Miacis;* and a similar series, less exact in its earlier stages, through which the cats are traced back to the same common ancestor. There is no serious "gap" in the line through which the dogs are traced back to the Lower Eocene *Miacis,* but the Eocene ancestors of the Felidae are represented only by a number of European genera imperfectly known and apparently not very close to the direct line of descent. The "gap" between cats and dogs is very much reduced in the Oligocene as compared with the present day; Oligocene dogs have many of the primitive characters of cats; Oligocene cats have many of the primitive characters of dogs; and both are much nearer in every way to *Miacis*. Dr. Clark's statement is evidently intended to give the impression that the "gap" between them is not reduced as we trace them backward. That is very far from being correct.

Thirty years of research and field collecting for the American Museum, studying especially fossil Carnivora and horses, are the basis of the above conclusions. The original literature on the Equidae is summarized in an article on the "Evolution of the Horse" in the *Quarterly Review of Biology,* April, 1926. The original literature on fossil cats and dogs

is scattered through many publications; my own contributions chiefly in the American Museum Bulletin. But in both groups, and especially in the Carnivora, a great part of the evidence has not yet got into print. I suggest that any one indisposed to accept these conclusions should examine the evidence, published and unpublished, on which they are based, with the object not of proving a theory but of discovering the truth. Some authors seem to believe that unpublished evidence has no right to be considered in a scientific discussion. This may be one of the rules of the game, if science is merely an academic exercise. But if our object is not to play a game but to get at the real truth as to the history of life, it is surely most foolish to disregard any evidence that may help us to a conclusion.

I leave to others the general criticism of Dr. Clark's "new" theory of evolution—merely remarking that the idea of separate origin of the major phyla of animal life was a commonplace of discussion when I went to college in the late eighties, and still remains an open question so far as I know. For the rest, his statements seem to me gravely misleading as to the actual facts of phyletic evolution, although worded in so vague a way as usually to escape being absolute misstatements.

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THE PRACTICAL SIGNIFICANCE OF INCREASING THE DAILY LIGHT PERIOD OF WINTER FOR STRAWBERRY BREEDING

A STUDY of the time of ripening of some of the standard strawberry varieties grown in the southeastern states from Maryland to Florida indicates that their relative earliness or lateness varies with the locality. In central Florida, fruit of the Missionary, the leading variety, begins to ripen in early winter and considerably earlier than Klondike. Farther north at Willard, N. C., the Missionary is no earlier than Klondike but nearly three weeks earlier than Howard 17. Still farther north at Glenn Dale, Md., the Missionary, Klondike and Howard 17 ripen at approximately the same time.

These results correspond to those reported by Bradford[1] for the peach and apple. He noted that differences in the flowering period in peach varieties might be masked at Columbia, Mo., while farther south the same varieties showed striking differences. He correlated this behavior with a rest period. The Missionary and Klondike strawberries, however, have no definite rest period and plants of these sorts set in the fall in Florida grow vigorously throughout the winter. Moreover, when taken into the greenhouse at Washington in the fall they continue growth throughout the winter. Other differences also showed up in the warm greenhouse. Both varieties blossomed but the Klondike made the stronger leaf growth. From this it would appear that Klondike is better adapted to the very short days of midwinter in the reduced light intensities of the greenhouse. Both sorts responded far more to the increase in temperature than did most northern sorts. In fact, when taken into the greenhouse in October the Howard 17 made practically no growth whatsoever.

A study of the behavior of these varieties in the greenhouse during the short days of the winter in response to increased daily light exposures obtained by supplementing the normal illumination period from sunset to 10 P. M. has shown still other differences. Two-hundred and one-hundred-watt lights with reflector shades were placed approximately sixteen inches above the ground surface so that the area lighted by each was seven square feet. The plants were given the supplemental light from October 20 to January 19. Growth was not as vigorous under the 100-watt lights as under the 200-watt lights, but the different varieties responded for this three-month period in the same way under the 100 as under the 200-watt lights.

When the daily light period in the greenhouse was increased by the use of the electric lights the Missionary variety responded more quickly than the Klondike, while the Howard 17 still made almost no response. Other northern sorts made varying responses to this increased daily illumination, some making almost no growth, others a growth almost as vigorous as the Missionary even though making almost no growth under the normal winter day. The tests, so far, indicate that in contrast to peaches and apples, some varieties represented by the Missionary and Klondike seem to have no rest period; other varieties apparently "rest" in the greenhouse under the normal short days of low light intensity but grow vigorously when given an increased daily light period; while still others which made very little growth when brought into the greenhouse on October 20 or December 10, started to grow vigorously when brought in February 1, and may, perhaps, have a rest period of the type of the peach and apple. Greater intensity, different quality or longer duration of artificial light than were used might, of course, have broken the rest period of this last group. English varieties, represented by the John Ruskin and Jucunda, and an Alaskan variety were among the least responsive to increased daily light periods even when brought into the greenhouse as late as February 1. This behavior

[1] F. C. Bradford, "The Relation of Temperature to Blossoming in the Apple and the Peach." Mo. Agr. Exp. Sta. Research Bul. 53: 1–51. 1922.

suggests their need of a very long daily light period as occurs in England and Alaska during the growing season.

Among the new varieties originated by the U. S. Department of Agriculture, U.S.D.A. No. 659 has been found especially well adapted to North Carolina where it is as early as Missionary, one of the leading commercial varieties of that state. When grown in the greenhouse in midwinter, with the daily light period increased by electric lights it responds even more quickly than Missionary. This suggests a better adaptation than Missionary to southern conditions where the spring growth occurs under short days. Other selections resulting from breeding work tested under increased daily illumination in midwinter have shown widely different responses, some corresponding to that of Missionary and others to that of such varieties as Howard 17.

Because the daily light period and the amount of light received in a day varies so widely for the different parts of the winter and because strawberry varieties respond so characteristically to additional light, results obtained at different times during the winter may be quite different, yet afford valuable data in helping to understand the normal varietal behavior in the field where most successfully grown. The response of about 140 sorts suggests the possibility of a classification of new originations and introductions on the basis of their rest periods, their response to temperature and to additional light as a first step in determining their regional adaptation.

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THE PRECISE EXPRESSION OF "DRYNESS"

IN referring to the viability of algal resting cells over long periods under comparatively dry conditions, Otis[1] has given an example of the need, in a great variety of comparative studies, of an exact method of expressing moisture conditions or degrees of dryness so that different observations may be correlated. Otis mentions a reported case of algae living for seventy years in stored soils containing from 3 to 10 per cent. of moisture. These quantities mean nothing without a knowledge of the type of soil involved, but probably imply enough "free" water in the soils so that the resistance to drying of the algal cells was not taxed in the slightest; in fact it is conceivable that the cytoplasm might never have been strictly dormant during all this period as conditioned by dryness. On the other hand the same author refers to a medium of small twigs, needles and rock fragments, on which algae are at present being stored, which is "very dry." It undoubtedly makes a good deal of difference to these algae whether the medium was "dried," and is now being held, in an atmosphere of 30 per cent. or one of 90 per cent. relative humidity. It is an accepted principle that the algae, the rough material, and the atmosphere of the storage jar must be, after a short time, in vapor-pressure equilibrium; it is, therefore, a perfectly simple matter to express the moisture condition of the entire system, in such a case, in concrete terms, of which the relative humidity at any moderate temperature is the simplest. It is also a simple matter to measure the state of the system for such an expression by placing weighed samples of the material in desiccators whose relative humidities have been predetermined by placing in their lower chambers various mixtures of water and sulphuric acid, or other chemicals. The gain or loss of weight by the sample indicates its position in the scale with all the precision necessary, provided the different desiccators vary in their humidities by steps of not more than 10 per cent. The method gives a reference point for moisture conditions on a great variety of materials whose physical properties vary so widely that direct comparisons of "moisture contents" are meaningless or impossible. It is, of course, not directly useful for materials whose moisture condition is above the lower limit of "free" water, for example, wood above the fiber-sat. point, or soils above the "wilting coefficient."

The writer has found in studying the viability of coniferous tree seeds that "air-dry" is entirely too indefinite an expression for indicating the status of seeds placed in storage. Depending upon the weather conditions, the presence of artificial heat indoors, etc., this term might mean drying to equilibrium with atmospheres of 60 per cent. or of 20 per cent. relative humidity, which in turn might mean the difference between 5 per cent. and 3 per cent. moisture content of the seed itself. With at least one species, a critical condition of dryness, affecting viability within a short time, appears to be reached at equilibrium with about 25 per cent. relative humidity. At least, small differences in this region may be of considerable importance. Hence the need for a precise method both of controlling and of expressing the condition in living materials.

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THE STONING OF A MINOR PROPHET

THE intuition of poet or artist has on occasion been responsible for significant predictions in the

[1] Chas. H. Otis, "The Viability of Algae," SCIENCE, N. S., 68: 1754, August 10, 1928.

field of science. For obvious reasons, prediction to be orthodox must come from competent, not to say prominent, men of science. The prediction described below appears somewhat difficult to classify as either artistic or orthodox, but seems worthy of record.

During the winter of 1878–9 a rough Pennsylvania mountain school teacher, aged about fifty, ventured to express his belief in the coming of wireless telegraphy. For this he was mercilessly rebuked by one of the most distinguished physicists of America, then a man in his late thirties. This incident, described below in the words of an eye-witness, is all the more interesting because the physicist was a man of lively mind and intense natural curiosity. The eye-witness is an early graduate of Mount Holyoke.

It was the winter of 1878–9. The Teachers' Institute of Fayette County, Pennsylvania, was meeting at Uniontown in the courthouse.

Public-school teachers from all over the county—big towns, small towns, rich farming sections and mountain districts—were present.

This week's break in the routine teaching—the week between Christmas and New Year's—was an unusual opportunity for these teachers. There were sure to be on the program a few real celebrities—scientific, literary, musical and what-not.

In this particular year, Dr. ———— was the great light.

One of his talks was on telegraphy—the Atlantic cable and the marvelous achievements of Morse and Fields. At the close, opportunity was given for questions.

In the far corner of the court-room there arose a red-headed, rather unkempt individual whom we recognized as a teacher of one of the mountain districts—a man of at least forty.

This was his question: "Professor, don't you think that the time is coming when messages will be sent without connecting horizontal wires? Perhaps with only upright wires at each station?"

The learned professor turned upon the mountaineer all the force of his polished sarcasm. It seemed to us who were breathless listeners that the mountaineer must be properly punished for even thinking such a preposterous and unscientific possibility.

When Dr. ———— had finished, the man who had remained standing throughout his tirade quietly remarked, "That's all right, Professor, but there are some folks in this room who will live to see just the thing that you say can't happen."

P. B. S.

SCIENTIFIC BOOKS

Conditioned Reflexes. An Investigation of the Physiological Activity of the Cerebral Cortex. By I. P. PAVLOV, director of physiological laboratories in the Russian Academy of Sciences and the Institute of Experimental Medicine. Translated and edited by G. V. ANREP, MD., D.Sc., lecturer in physiology in the University of Cambridge. Cloth. Price, $9.00. 430 pp. 18 illustrations. New York: Oxford University Press, 1927.

Lectures on Conditioned Reflexes. 35 Years of Objective Study of the Higher Nervous Activity (Behavior) of Animals. By IVAN PETROVITCH PAVLOV, M.D., director of the physiological laboratories, Institute of Experimental Medicine and Academy of Sciences; formerly professor of physiology, Military Medical Academy Leningrad. Translated from the Russian by W. HORSLEY GANTT, M.D., B.Sc., with the collaboration of G. VOLBORTH, M.D. 414 pp. Bibliography and index. Price, $6.50. International Publishers, New York. 1928.

WITHIN the short period of one year there has been rendered available for English-speaking people the monumental work of Pavlov and his pupils on conditioned reflexes. The Anrep translation comprises essentially a stenographic account of a series of lectures given by Pavlov at the Military Medical Academy of Petrograd. The Gantt translation consists essentially of a series of papers and addresses delivered by Pavlov before various medical and scientific organizations in different parts of the world during the last twenty-five years. The first book is a more systematic development of the experiments and interpretations of conditioned reflexes. The second book, although bearing the same title, is essentially a source book of experimental data in that here Pavlov gives somewhat more in detail the methods and results in the various experimental attacks.

Pavlov is universally recognized as the pathfinder in the field of nervous physiology and animal behavior now grouped under the term "conditioned reflexes." Conditioned reflexes are those reactions or behavior mechanisms developed after birth as a result of individual experience and learning or as a result of particular developmental stages of the individual as distinct from the simpler and less variable reflexes laid down in the structural relations of the individual and already perfected at birth. The problem of analysis and development of conditioned reflexes is therefore one of highest interest biologically, and of the highest practical importance in education and in the problems of social control. In Gantt's translation there is an interesting chapter dealing with the life of Professor Pavlov himself. This biographical sketch and the prefaces occupy the first forty-six pages of the book. The bibliography at the end of both translations contains citations of all publications on the subject of conditioned reflexes from Pavlov's own laboratory in Petrograd. It is interesting to note that practically all these publications appear un-

der the name of Pavlov's students; only occasionally does Pavlov's own name appear on a title.

The reader who is familiar with Pavlov's earlier researches on the digestive glands, for which he received the first Nobel prize awarded in the medical sciences, will be impressed with the continued high quality of mental activity disclosed in the present volume by the eighty-year-old investigator. The reader will also be impressed with the fact that Pavlov has become more speculative with advancing years. While Pavlov, on almost every page, emphasizes the necessity and importance of strict objectiveness in science, he almost as frequently disregards it, especially in the interpretations of sleep, and inhibitions and in the extension of data from dog to man. It is to be remembered that nearly all the objective experiments on conditioned reflexes reported from Pavlov's school have been done on the dog and mainly in connection with the feeding behavior. The philosophical aura permeating the present volumes adds more interest in the work on the part of the general reader than it contributes to the progress of science. As an instance in point might be mentioned the two short chapters in Gantt's translation headed: "Reflexes of Purpose," and "The Reflexes of Freedom." In the chapter on "Reflexes of Purpose" occurs the following paragraph:

> When the negative features of the Russian character—laziness, lack of enterprise, and even slovenly relations to every vital work—provoke melancholy moods, I say to myself, No, these are not real qualities, they are only the veneering, the damning inheritance of slavery. It made a parasite of the master, freeing him, through the unpaid work of others, from the practice of natural and normal striving to obtain his daily bread for himself and family, from the necessity of making his way in life; and it left the reflex of purpose without exercise in the fundamental habits of living.

Under the heading of "The Reflexes of Freedom" after a brief description of a kind of behavior of only one dog out of many hundreds of dogs investigated, Pavlov ends with the following story from fiction:

> In Kuprin's story, "River of Life," there is described the suicide of a student who was tormented by his conscience after having betrayed his companions to the police. From a letter of the suicide it was evident that he was made a victim of the reflex of slavery inherited from his mother, who was a *prijivalka*.[1] If he had had an insight into his condition, he would first have understood his limitation, and secondly he might by systematic measures have developed control and successful suppression of this reflex.

[1] A parasitic servant of the nobility.

Gantt's translation contains some needless repetitions and, occasionally, interpretations that are abandoned in subsequent addresses. Neither volume contains any references to or accounts of investigations in the same field in laboratories other than Pavlov's. These investigations have frequently confirmed, but sometimes disagreed with Pavlov's actual findings or interpretations. It would have been interesting and valuable to have had the aged investigator's review of and reaction to the entire aspect of conditioned reflexes up to the year 1928. But we must be grateful to have at least the main body of contributions from Pavlov's own laboratory accessible in English. These volumes are of compelling interest to every educated man and woman. They are opening preludes in a problem as baffling as it is important. Pavlov himself would be the last man to describe them as a scientific finale. But we do actually seem to be making progress in the analysis of behavior on the basis of chain reflexes, conditioned by experience, memory and hormones. The reader will forget the minor defects in the books in contemplating, as Professor Cannon says, "the splendid example of industry and devotion to science which the first explorer in the field of conditioned reflexes has given during his long life." It is the unanimous hope of American physiologists that nothing may prevent Professor Pavlov's stimulating presence at the International Physiological Congress in Boston in August this year.

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The Story of the Moon. By GARRETT P. SERVISS. Appleton and Co. xii + 248 pp. 1928.

THIS is a book for the amateur astronomer and for the general reader, written in a simple manner and scientifically sound. It is divided into five main parts. The introduction contains a non-technical explanation of fundamental facts about the moon. Among these are described the origin and the orbit of the moon, its effect on terrestrial tides and the causes of lunar and solar eclipses.

The next three sections are devoted to a very thorough topographic study of the moon, which is made more intelligible by a series of fine photographs, obtained in 1903 and 1904 by Professor G. W. Ritchey and Mr. James Wallace at the Yerkes Observatory. The age of the moon, as pictured in these photographs, varies from 3.85 to 26.89 days, and all the points of interest are mentioned in the descriptions. Each important object is usually mentioned several times in connection with each photograph upon which it appears, under the changing conditions

of sunlight. The regions of unusual craters such as Tycho, Copernicus, Theophilus and those around Mare Serenitatis and Mare Imbrium are described more fully in the final chapter of the book. The whole text is in the form of a dialog between the author and a friend who starts with no knowledge of the subject.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE DISSECTION OF THE SPIRAL VALVE OF SQUALUS ACANTHIAS

A SATISFACTORY dissection of the spiral valve of *Squalus acanthias* usually proves to be a difficult task for students of comparative anatomy. In order to expose enough of the valve to make its analysis possible, a considerable portion of the intestinal wall must be removed. If the method of dissection employed involves the removal of a single longitudinal strip of the intestinal wall extending the length of the intestine, it follows that the spiral valve must suffer serious mutilation.

Fortunately, the lines of attachment of the spiral valve are approximately indicated at the surface of the intestine by branches of the anterior mesenteric artery. This anatomical arrangement makes it possible to remove portions of the intestinal wall without danger of damage to the spiral valve. There follows a brief description of one method of dissection which has proved quite satisfactory.

Fig. 1 shows an undissected intestine with broken lines outlining portions of the intestinal wall to be excised. Fig. 2 shows the appearance of the intestine after dissection. By this method of dissection the intestinal wall is reduced to a mere skeletal support for the spiral valve which is left intact and sufficiently exposed so that its structure can be easily studied.

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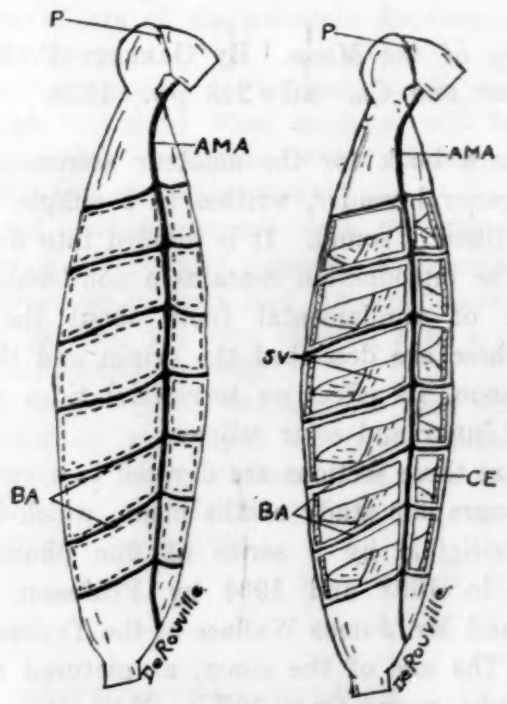

Fig 1. Fig 2.

AMA, anterior mesenteric artery; BA, branch arteries; CE, cut edge of the spiral valve; SV, spiral valve; P, pylorus.

SPECIAL ARTICLES

X-RAYS AND MUTATIONS

ONE of the paragraphs in the article entitled "Biological Effects of X-rays," by H. K. Svenson in SCIENCE 69: 361, March 29, 1929, may lead to a misunderstanding of the experiments to which reference is made. The results of the experiments were published jointly by the present writer and H. K. Svenson in three papers: "An Effect of X-rays on the Linkage of Mendelian Characters in the Second Chromosome of *Drosophila Melanogaster*,"[1] "Crossing over in the Second Chromosome of *Drosophila Melanogaster* in the F_1 Generation of X-rayed Females"[2] and "A Comparison of the Effects of X-Rays and Temperature on Linkage and Fertility in *Drosophila*."[3] The aims of the experiments are correctly expressed in the above titles of the papers describing them. Mutations were, of course, not to be ignored if they were found; on the other hand the experiments were not planned with a view to testing the possiblity of producing mutations by X-ray treatment. Nor were the experiments as carried out particularly favorable to the discovery of mutations.

Records of the four experiments referred to are given in two papers.[1, 3] In these experiments the female parent only was X-rayed, and the experiments were followed only to the F_1. In these F_1 only one, that from the mother, of any two homologous genes could have been exposed to X-rays except in the rare cases of non-disjunction. A recessive mutation if produced by the X-rays could, therefore, be observed only in the males and then only if it occurred in the X-chromosome. Dominant mutations, although on the whole rarer than recessive mutations, could be observed in either the male or the female F_1. The records of the experiments given in the papers referred to showed that there was observed a total of 49,360 F_1 males, of which 20,069 were the offspring of X-rayed mothers; of these 20,069 males, 5,513 came

[1] *Genetics*, 9:70–89. 1923.
[2] *American Naturalist*, 58: 311–315. 1924.
[3] *Genetics*, 9: 588–608. 1924.

from germ cells which had been exposed during the more sensitive period, *i.e.*, from one to six days previous to laying. The number of flies observed in which visible X-ray mutations might be expected to occur was therefore not large.

In the experiments reported in the other paper[2] sibs which were F_1 of X-rayed females were mated and the resulting F_2 of the X-rayed observed. Eleven fertile matings were made of the F_1 of the X-rayed females and five of the F_1 of the control. It has already been stated that a visible recessive mutation in an X-rayed X-chromosome would appear in the male F_1. A visible recessive mutation in an autosome, on the other hand, would not appear even in the F_2 unless the mating was between two F_1 individuals each carrying the mutated gene. Such a mating is altogether beyond probability under the conditions of the experiment, since it would involve the occurrence of the mutation twice in a small number of eggs and then the accidental mating of the two individuals. So far, then, as a test for the occurrence of visible mutations the experiment involving the F_2 of the X-rayed has little to commend it over an experiment involving only the F_1. Furthermore, as the F_2 were the offspring of eleven F_1 of X-rayed parents the observations in this case involve really only eleven X-rayed germ cells.

Of more importance is the fact that all three experiments, dealing as they did with crossing over, involved the counting of large numbers of flies and therefore offered little opportunity for critical scrutiny of the individual flies except as regards the mutant characters involved in the crossing over determinations.

The data of the experiments described in the second paper[2] do, however, give some information regarding the possible occurrence of lethal mutations, a matter which, not being part of the original plan of the experiments, did not come up for consideration at the time. Going over the data from this point of view the present writer finds in the counts of the offspring of the eleven fertile F_1 of the X-rayed females three cases of irregular viability ratios suggestive of lethals in the second chromosome and in the counts of the offspring of the five control F_1 one case strongly indicating a sex-linked lethal.

The experiments referred to by Dr. Svenson in his article which were carried on in collaboration with the present writer and have been discussed above can, therefore, in no way be regarded as giving evidence against the possibility of inducing mutations by X-rays.

From time to time in experiments conducted by the present writer in this laboratory and at the Marine Biological Laboratory at Woods Hole mutations have appeared among the offspring of X-rayed females, a notable case being that of "yellow" which occurred twice in one experiment among 2,692 gray males which were the F_1 of X-rayed females and not among the 1,042 F_1 of control females which were sisters of the X-rayed females. The association of the yellow body color with the other mutant characters involved in the experiment rendered contamination very unlikely, and the fact that one of the yellow flies was a white miniature and the other an eosin miniature and the fact that they occurred in different culture bottles and one only in each culture bottle makes it extremely probable that they arose independently. The yellow males were mated to gray females and yellow stocks extracted which were bred for several generations. However, as statistical evidence of the induction of a mutation, two in the F_1 of the X-rayed as against none in the F_1 of the control is not significant. In a subsequent experiment performed, however, under somewhat different conditions no yellow flies occurred.

The above discussion has been limited to gene mutations or at least to intra-chromosomal mutations. It may properly be said, however, that the induction of non-disjunction of the sex-chromosome which the present writer had shown can be produced by X-rays[4] is in effect the induction of a chromosomal mutation.

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THE OCCURRENCE OF PODSOL SOILS IN QUEBEC PROVINCE

RUSSIAN soil scientists apply the term *podsol* to soils occurring in cool, humid climates which, due to deficiency of calcium carbonate and the formation of organic acids, have suffered leaching of aluminum and iron sesquioxides from their A horizons. Typical podsol soils have a high accumulation of semi-decomposed carbonaceous material in the surface soil, an "ashes-like" layer below this which is very low in organic matter, and are ill-drained. More or less well-defined hardpan formation is characteristic.

Work with Quebec surface soils and subsoils in this laboratory during the last fifteen months has shown a prevalence of the podsol type in certain districts. The great accumulation of semi-decomposed organic matter in the surface six to eight inches of the podsol soils studied is especially noteworthy. The soils of limestone origin studied, which contain a fair amount of calcium and magnesium, as a rule do not show nearly so high an amount of carbon in their surface soils as do the soils originating from igneous rocks. Those limestone origin soils which do have a rather high amount of organic carbon in their surface soils

[4] SCIENCE, N. S., Vol. LV, pp. 295–297; SCIENCE, N. S., Vol. LVII, pp. 503–504; *Jour. Exp. Zool*, Vol. 39, pp. 381–432.

have also a relatively high amount of organic carbon in their subsoils, *i.e.*, even down to two feet depth.

Podsol soils have been identified as such in Brome County, near the Vermont border of Quebec, in Jacques Cartier County on the Island of Montreal, and in Hull County near the confluence of the Ottawa and Gatineau Rivers. In each of these cases small areas of non-podsolized soils of limestone origin occur near the larger podsol areas.

Some of the characteristics of the Quebec podsols so far studied in this laboratory are shown in Table I:

TABLE I

CHARACTERISTICS OF QUEBEC PODSOL SOILS STUDIED

	Surface 8″ of Soil	Subsoil—Taken between 12 and 24″ deep
Carbon	High—3.42–4.72 per cent.	Low—0.79–1.72 per cent.
Nitrogen	High—0.25–0.45 per cent.	Low—0.08–0.15 per cent.
Color	Medium to light brown	Light brown to gray
Lime requirement	Very high—5721–11,378 lbs. $CaCO_3$ per acre	High, but lower than surface—3784–6557 lbs. $CaCO_3$ per acre
Hydrogen ion concentration	High—pH 4.97–5.71	High—pH 4.94–5.76
Water-retaining capacity	Very great	Much less than surface
Percolation rate	Very low	Higher than surface
Total Ca and Mg	Low — each below 0.5 per cent. of air-dried soil	Low—but slightly more than surface soil
Water soluble Ca and Mg	Low—23–33 ppm. Ca; 13–18 ppm. Mg in air-dried soil	Lower than surface—9–16 ppm. Ca; 3–5 ppm. Mg in air-dried subsoil
Concentration of No_3^-, K^+, $PO_4^{\equiv}$, & $SO_4^=$ in water percolates	Low	Much lower than surface
Loss on ignition	High—10.52–14.58 per cent. of oven-dried soil	Low—2.67–5.55 per cent. of oven-dried subsoil
Hygroscopic moisture	High—2.66–3.24 per cent. of air-dried soil	Low—0.89–1.96 per cent. of air-dried subsoil
Apparent specific gravity of fraction of air-dried soil passing 2 mm mesh sieve	Low—0.899–0.969	1.158–1.338

Further work on this question is in progress.

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THE NATIONAL ACADEMY OF SCIENCES

AT the annual meeting of the National Academy of Sciences, held in Washington on April 22, 23 and 24, the following papers were presented:

The regeneration of minute sectors cut from the bodies of nemertean worms: W. R. COE (introduced by Lorande L. Woodruff). When an individual of *Lineus socialis*, a nemertean found abundantly on our Atlantic coast, is cut into numerous transverse sections, each of these, with the exception of pieces cut through or anterior to the brain, quickly restores the missing organs and regenerates into a miniature of the original worm. If the transverse sections are split longitudinally along any plane, regeneration likewise occurs. Furthermore, if a section is split into four quadrants or even into six sectors, each piece may produce a minute worm of normal proportions. If, however, the sectors are incompletely separated posteriorly curious types of multiple individuals are sometimes formed. These may eventually lead to the production of normal worms either by a process of regulation whereby the less active partial individual is absorbed into the body of a more dominant individual or, more frequently, two or more of the partial individuals separate from the multiple group to develop into normal, but extremely minute, replicas of the original worm. Sectors incompletely separated at the anterior end may likewise produce multiple groups, but in this case the partial individuals are joined anteriorly and only a single head is usually formed. Eventually the single head forms a new body and separates from the multiple group as a complete individual, and the process may be repeated until all the partial individuals separate or disintegrate. Because of the high specialization of their tissues and the stability of their polarity the nemerteans are particularly favorable subjects for detailed analyses of the processes which are concerned in the dedifferentiation and redifferentiation of the cellular elements participating in the regenerative phenomena.

The physiology of sympathectomized animals: WALTER B. CANNON. Bilaterally sympathectomized animals have lived in the laboratory in good health, performing normally all the routine functions, for many months. The claims that the superior cervical sympathetic ganglia or the mesenteric nerves are essential for life are thus disproved. Additional removal of one adrenal and demedullation of the other demonstrates that the chromophil tissue is not of vital importance. Unilateral sympathectomy of young kittens has not resulted, as they have grown to adult size, in any demonstrable difference in bilaterally symmetrical organs. Sympathectomy does not prevent the female from performing the functions of reproduction. After bilateral sympathectomy emotional excitement causes no erection of hairs, no consistent increase of blood sugar, no polycythemia, no relative increase in mononuclear cells and, as shown by a few

observations, no marked rise of arterial blood pressure. Sympathectomized animals are very sensitive to cold; having lost the means of conserving heat they seek warm places, and when placed in a frigid environment they lose heat more rapidly than normal animals. The basal metabolism usually falls somewhat after sympathectomy, especially after the cervical portion is excised, but as a rule removal of the sympathetic chains does not reduce the basal metabolic rate more than 10 per cent. The slight effect resulting from sympathectomy raises the question as to the function of the sympathetic. This question is considered with regard to the natural conditions which excite the sympathico-adrenal system, and the conclusion is drawn that this system, dispensable in the protected conditions of the laboratory, finds its great service at times of critical emergencies when it adjusts the internal organs of the body for use of the mechanisms responding to external exigencies.

Chemical bacterial analysis and the coordination of chemical and biological investigations in the study of the tubercle bacillus cell: TREAT B. JOHNSON.

Chemical investigations of biologically active lipoids of tubercle bacilli (illustrated): RUDOLPH J. ANDERSON (introduced by Treat B. Johnson).

The reaction of the lipoid fractions from the tubercle bacillus, human strain H 37, when introduced into the tissues (illustrated): FLORENCE R. SABIN, C. A. DOAN and C. E. FORKNER.

An experimental method for determining the activity of convalescent poliomyelitus serum: SIMON FLEXNER and CORNELIUS P. RHOADS.

The relief of experimental pneumonia: YANDELL HENDERSON, P. N. CORYLLOS, H. W. HAGGARD, G. L. BIRNBAUM, and E. M. RADLOFF. In patients after surgical operations the development of the so-called massive collapse, or atelectasis, of the lung is an essential factor or stage in the development of pneumonia. It has been found (Scott and Cutler) that deep breathing induced by inhalation of carbon dioxide dilates the lung again and thus overcomes atelectasis and prevents the development of pneumonia. In medical pneumonia also the development of atelectasis (Coryllos and Birnbaum) plays an important part by closing the air tubes and thus obstructing the normal channels of drainage. The purpose of the experiments to be reported was to determine whether the deep breathing induced by inhalation of carbon dioxide will open up closed areas of the lungs in pneumonia. In its essentials this treatment is like that introduced by Henderson and Haggard and now widely used by the rescue crews in cities for the treatment of carbon monoxide asphyxia. In the experiments dogs were narcotized and a virulent culture of pneumococci type II was introduced through a bronchoscope into the right lung. Pneumonia generally developed, and in nearly all such cases, if not treated with inhalation of carbon dioxide, the animals died in from one to three days. If, however, soon after the development of pneumonia the animals were placed in an atmosphere of 5 to 7 per cent. carbon dioxide, the collapsed and pneumonic areas of the lung cleared up to a large extent and many of the cases made a complete recovery. X-ray pictures will be shown illustrating the collapse of the lung induced when an obstruction is placed in a bronchus and the rapid redistention of the lung when the animal is placed in a chamber containing 5 to 7 per cent. carbon dioxide in air. Similar pictures will be shown of atelectasis in dogs infected with pneumonia, together with the X-ray pictures showing the redistention of the lung resulting in such cases from the deep breathing induced by inhalation of carbon dioxide. These results are not to be interpreted as promising similar relief in clinical pneumonia; they merely open interesting possibilities. But, with other evidence, they do prove that atelectasis is a factor in pneumonia, and that inhalation of carbon dioxide is an effective means of counteracting atelectasis and reinflating the pneumonic lung.

Measurements of 100 members of the academy and what they show: ALEŠ HRDLIČKA. For five years now an effort has been made to obtain reliable physical, and some physiological, data on the members of the National Academy of Sciences. The membership of the academy is limited to 250; the mean actual membership has been by about twenty smaller. These men have been rigidly selected from among the foremost representatives of the different sciences. They are, therefore, a selected group of high-class brain workers. The problem was whether and how these men differed in physique, in strength, and above all in the development of their head, from the general population. The old idea of an eminent man of science was largely that of one-sidedness of mind with a rather frail or neglected body. Approximately one half of the members were examined, without any choice. The most striking fact brought out through this work is that these men, barring rare exceptions, are in no way inferiors, but rather superiors in physique, strength, health and longevity, as compared to the American and even the Old American population at large. It is decisively not a case of strong minds in weak bodies, but strong minds with strong constitutions. This is a fact of much significance and that not merely to anthropology. Another important fact is that these brain workers show a high average size of the head. The head (and hence presumably also the brain) of the members of the academy exceeds in size not only that of the population at large, but even that of the well-educated and professional Old Americans. There are many additional interesting details, but it is clear that outside of prevalence of above-the-average physique and above-the-average size of head, the highly talented men of science conform in their traits with the racial groups to which they belong. The essential results of the study here dealt with are, therefore, the apparently conclusive proofs that, in science at least, the strongest and ablest healthy minds go generally with strong healthy bodies; that intensive, prolonged mental work is concomitant with larger-than-average head and brain, and, finally, that such intensive mental work evidently does not tend towards a shortening of the life of the workers.

The reality of the great star streams: JAN SCHILT (introduced by Dr. Frank Schlesinger). In 1904 Kapteyn showed that the proper motions of the stars were directed towards two definite points in the sky. Although the more conspicuous motions seemed to be in either direction along a certain axis in space, it was realized that many stars deviated considerably from this main direction. Schwarzschild showed that Kapteyn's discovery could equally well be interpreted by the introduction of an ellipsoidal distribution of velocities as by Kapteyn's assumption of two separate streams. Kapteyn's interpretation has been illustrated by a comparison with two swarms of bees flying through each other, while the ellipsoidal theory is comparable with ships sailing on a wide river. In the former case each bee belongs to one definite swarm, although the direction and velocity of motion for an individual may deviate considerably from its swarm. In the second case we can not assign each ship to a definite stream. Slow craft will be found especially plying across, whereas the faster ships will show a tendency to sail either up or downstream. The controversy between the idea of the separate streams and the unitarian preferential motion theory has not been settled hitherto by observations. The tendency has been to favor the preferential motion rather than the streams, because it can much more easily be put into mathematical formulas. Kapteyn had the proper motions of about 3,000 of the brighter stars at his disposal. Nowadays more than ten times as many are known, and we have, moreover, the radial velocities for several thousands of stars. The discussion of parts of this enormous material has revealed the fact that the stars in a certain portion of space have, in general, a systematic velocity with respect to the stars in a distant portion of space. Several astronomers have tried to explain these systematic motions on the basis of the ellipsoidal theory. The recent results obtained from the discussion of proper motions and radial velocities at Yale Observatory confirm the existence of two great star streams which, however, are not the same as Kapteyn's. The stars in general to the tenth visual magnitude appear to be divided into two streams. The points of convergence are in Orion and Canis Major, at about 10° North declination and 40° South, respectively. The velocity of the sun is 8 km per second with respect to the northern stream, and 22 km per second relative to the southern. The proportion of stars belonging to stream N and to stream S varies with the region of the sky. But as a whole, about equal numbers belong to the two. Relatively to each other the streams move to and from a point in the galaxy at galactic longitude 58°, situated in Cygnus, with a velocity of 19 km per second.

The use of time-corrected films in hydraulic experimentation (illustrated): TH. REHBOCK (by invitation).

Comets and terrestrial magnetic storms: E. O. HULBURT and H. B. MARIS (introduced by Joseph S. Ames). A recent theory of the authors attributed terrestrial magnetic storms and auroral displays to the effect of unusual flares of ultra-violet light from the sun falling upon the terrestrial atmosphere. Such flares would be expected to cause changes in comets, and therefore comet changes should be closely connected with magnetic storms. This connection is supported by the evidence brought out in the present paper in a discussion of the behavior of thirty-one comets scattered through the years 1848 to 1927. A general statistical result was that in the month preceding each comet's activity there occurred on the average 6, 4, 2.9 and 1.5 times as many magnetic storms of strength 4, 3, 2 and 1, respectively, as there should have occurred according to chance. Outstanding comet changes, twenty-eight in number, followed on the average five days after strong magnetic storms. The positions of the comet, sun and earth at the epochs of the comet changes indicated that the solar flare was in a wide angle, contrary to the narrow beam hypothesis of Maunder.

Elements in the sun (illustrated): CHARLES E. ST. JOHN.

Further observations of stellar energy spectra: C. G. ABBOT. Author explained his attempts to improve the sensitiveness of the Nichols radiometer in order to prepare the way towards observing the distribution of energy in the spectra of the fainter stars. He employs vanes of house-flies' wings, cut approximately 1/25 inch tall by 1/75 inch broad as the ray-receiving surfaces. To prevent transfer of heat from front to rear, the vanes are in two groups of three each, placed parallel, with intervening gas-spaces of 1/250 inch. The front member of each group is blackened so as to be warmed by absorbing the spectral rays. Being suspended by excessively fine fibers of rock-crystal, the system, shaped like an inverted T, responds to the reception of rays by turning until the torsion of the fiber equals the kick of the gas molecules on the warmed surface. Rotations were measured by the deflections of a ray of light reflected from a tiny platinized mirror of very thin microscope cover-glass. The observing scale was at nearly twenty feet distance, and deflections thereon could be read almost to one second of arc of rotation of the mirror. The suspended system weighed but 0.9 milligram (3/100,000 ounce). The system was suspended within an optically worked tube of fused quartz, and surrounded by hydrogen gas at 1/5,000 atmospheric pressure. Experiments had shown that this gas, while giving nearly equal radiometer effects to air, was so much less viscous as to avoid excessive damping of the free swing of the suspension. Air at atmospheric pressure behaved like molasses to the vanes, so that the upper end of the quartz fiber could be rotated over forty complete turns before the suspension itself began to rotate. With this apparatus, author was able to make satisfactory observations of the energy spectra of eighteen stars and the planets Mars and Jupiter. Several stars fainter than second magnitude were observed, and the faintest was of 3.8 magnitude. From the results it is possible to estimate the diameters of the stars observed. Mars and Jupiter, as expected, indicated the solar type of spectrum.

(*To be continued*)